# Data Interpretation: Reading Your Report

**Biological**: Living plants or organisms.

**Chemical**: Parameters related to the chemistry of water.

**Physical:** Parameters that can be perceived using the senses, such as Secchi Disk transparency.

**Epilimnetic:** Of the upper thermal layer of the lake.

When you receive your annual report, the data, graphs, and explanations may seem overwhelming at first. Please read the "Observations and Recommendations" section carefully. Current and historical water quality trends for your lake and its tributaries are described in detail. You may find it helpful to refer back to the "Monitoring Parameters" section of your report to better understand the information provided in the "Observations and Recommendations" section.

The graphs in Table A display deep spot sampling data. The data tables in Appendix B summarize the current year and historic deep spot and tributary data by providing the annual mean and maximum and minimum values for each parameter sampled by your monitoring group.

In the "Observations and Recommendations" section, the deep spot data for most parameters sampled is compared to the respective New Hampshire median to provide an understanding of how the quality of your lake deep spot compares to other New Hampshire lake deep spots. The following table summarizes key **biological, chemical, and physical** parameters for all the state's lakes surveyed since 1976.

**Summer Epilimnetic Values of New Hampshire Lakes**

| **Parameter** | **#*** | **Min** | **Max** | **Mean** | **Median** |
|---|---|---|---|---|---|
| pH (units) | 780 | 4.3 | 9.3 | 6.5** | 6.6 |
| Alkalinity (mg/L) | 781 | -3 | 85.9 | 6.6 | 4.9 |
| Total Phosphorus (ug/L) | 772 | <1 | 121 | - | 12 |
| Conductivity (uMhos/cm) | 768 | 13.1 | 696 | 59.4 | 40.0 |
| Chloride (mg/L) | 742 | <2 | 198 | - | 4 |
| Chlorophyll-a (mg/m3) | 776 | 0.19 | 143.8 | 7.16 | 4.58 |
| Secchi Disk (m)*** | 663 | 0.40 | 13 | 3.7 | 3.2 |

** = the number of lake stations sampled*
*** = average pH reading; not average of hydrogen ion concentration*
**** = does not include "visible on bottom" readings*

Recommendations discussed in the "Observations and Reccommendations" section may include adding additional sampling locations and increasing the number of sampling events your monitoring group conducts. Expanding your sampling program will provide additional data that will help DES determine more accurate and representative trends and will also help identify pollution sources. Recommendations may also include encouraging your monitoring group to work with your lake association, watershed residents, and local officials to implement management practices to protect and improve lake quality.

After reviewing your annual report, discuss the recommendations with your monitoring group and lake association. Prioritize the recommendations according to your association's goals. Then, contact the VLAP coordinator to discuss the how to effectively implement an action plan.

# Data Interpretation: Graphs and Tables

There are two types of graphs in Appendix A, a line graph and bar graph, which present deep spot chlorophyll-a, transparency, and phosphorus data. Each graph conveys much more information to the reader than a table or verbal description could, so it is important that the readier is able to interpret these graphs.

## Line Graph

**Mean**: Average. To calculate the mean, the reading or concentration for a particular parameter on each sampling event is added together, which results in a total for the season. The season total is then divided by the number of sampling events during the season, which results in an average concentration or reading per sample event.

The line graph summarizes sampling results for the years your group has collected data, as shown in the example below. The graph shows the **mean** for a given year as an up-turned or down-turned triangle. The triangle points in the direction of more desirable values. For example, chlorophyll-a and total phosphorus have downward triangles, indicating lower values are better, while transparency has upward triangles, signifying higher values are more desirable.

Line Graph Depicting Historical Data

**Standard deviation:** A statistic measuring the spread of the data around the mean.

**Range:** Difference between the high and low values.

A measure of the spread of the data around the mean, or **standard deviation**, is shown as the vertical lines extending up and down from the mean. Standard deviation is similar to **range** except standard deviation is a more exact measure of variation. In this case, the lines indicating standard deviation on your graphs illustrate the amount of variation in the results for a particular test for all the times you sampled in that year. For example, if all the chlorophyll readings came back with similar results each time you sampled this year, then the amount of deviation from the average would be small. If there was a wide range of chlorophyll concentrations in the lake, then the deviation would be large.

**Regression Line:** A statistical tool used to predict trends in data.

Trends in the yearly data can be discerned by looking at the **regression line** and noting its direction and degree of slant. If the line is slanted downward (like this "\"), it indicates an improving trend in chlorophyll-a and total phosphorus, but a worsening trend in transparency. If the line is slanted upward (like this "/"), it depicts a worsening trend in chlorophyll-a and phosphorus, but an improving trend in transparency. The steeper the slope of the regression line, the stronger the trend. A horizontal regression line indicates the parameter is stable, neither improving nor worsening over time.

Do not draw absolute conclusions from annual data if the lake was only sampled once a year as it is difficult to determine representative trends with such a limited amount of data. Also, if the line graph shows a parameter worsening, review the data provided in Appendix B. Look for sampling events with one extremely high or low sampling result which could be considered an **outlier**. Outliers can **skew** the trend line. You need many years of data before trends become apparent, and ten years before they are considered statistically significant. After your lake has been monitored through VLAP for at least 10 consecutive years, we will analyze the deep spot data using linear regression analysis to determine if there has been an increase or decrease of the annual mean for chlorophyll-a, transparency, and total phosphorus since monitoring began.

**Outlier:** A value far from most others in a set of data.

**Skew**:A measurment of consistency, or more precisely, the lack of consistency.

**Median:** A value in an ordered set of values below and above which there is an equal number of values (i.e.; the 50% percentile). Medians are not affected by outlier data.

**Mean:** The average of a set of values. Means can be affected by outlier data.

**New Hampshire Median:** A descriptive statistic for data collected from all of the approximately 800 lakes in the state through the New Hampshire Lake Assessment Program.

**New Hampshire Mean**: A descriptive statistic for data collected from all of the approximately 800 lakes in the state for the New Hampshire Lake Assessment Program.

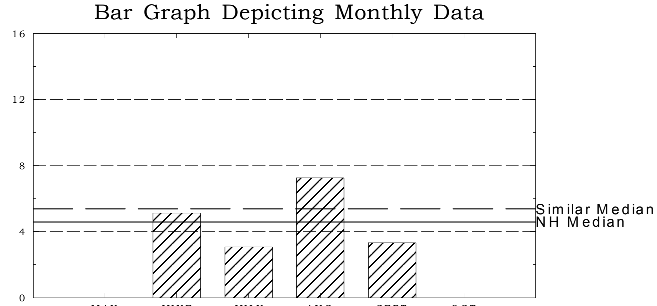
**Similar Median:** Using New Hampshire Lake Assessment Program data, New Hampshire lakes have been classified into ten categories based on lake maximum depth and lake volume. Median values for particular parameters have been determined for each of the ten groups.

The last element in the line graph are two reference lines. One reference line represents the **New Hampshire Median** for that particular parameter. The data from your lake can be compared to the **New Hampshire Median** to understand how the quality of your lake compares to the median value for all lakes in the state as a whole. The second reference line represents the **Similar Median** for that particular parameter. Using the **Similar Median**, the data for your lake can be compared to median values for lakes that are simila, based on lake volume and maximum depth. This simple classification scheme can be useful in better characterizing the quality of your lake.

## Bar Graph

The second type of graph is the bar graph. It represents the current year's monthly data for a given parameter. When more than one sampling event occurred in a month, the plotted value will represent an average result for that month. Consult Table 15 for individual sampling event results. The bar graph emphasizes individual values for comparison rather than overall trends and allows for easy data comparisons within one sampling season.

Bar Graph Depicting Monthly Data




## Tables

Tables in Appendix B summarize data collected during 2006 and previous years. Maximum, minimum, and mean values are given for each station by sampling year for most tests, where applicable.

## Lake Maps

**Bathymetric map**: A map that shows the topography of the lake's bottom; contours depict lake depths.

A **bathymetric map** in Appendix C shows the depth contours of your lake. A station map in Appendix C shows the name and location of the tributary and deep spot samples collected from your lake. If stations are missing, please make corrections and send the map to the VLAP Coordinator.

# Data Interpretation: Monitoring Parameters

## Biological Parameters

### Algal Abundance

**Phytoplankton**: Microscopic algae drifting through the water column.

Algae, formally referred to as **phytoplankton**, are photosynthetic plants that contain chlorophyll but do not have true roots, stems, or leaves. They do, however, grow in many forms such as aggregates of cells (colonies), in strands (filaments), or as microscopic single cells. They may also be found growing on objects, such as rocks or vascular plants, on the lake bottom or free-floating in the water column.

**Photosynthesis**: Producing carbohydrates for food with the aid of sunlight.

**Food chain**: Arrangement of organisms in a community according to the order of predation.

**Zooplankton:** Microscopic animals drifting through the water column.

**Oxygenated**: Holding oxygen in solution.

Regardless of their form, these primitive plants carry out **photosynthesis** and accomplish two very important roles in the process. First, they convert non-living compounds into organic, meaning living, matter. These tiny plants form the base of a lake **food chain**. Microscopic animals, formally referred to as **zooplankton**, graze upon algae like cows graze on grass in a field. Fish also feed on algae. Second, the water is **oxygenated**, aiding the chemical balance and biological health of the lake system.

Algae require light, nutrients, and certain temperatures to thrive. All of these factors are constantly changing in a lake on a daily, seasonal, and yearly basis. Therefore, algae populations and the abundance of individual species of algae naturally change in composition and distribution with changes in weather or lake quality.

**Chlorophyll-a**: A green pigment found in algae.

**Oligotrophic**: Low biological production.

**Eutrophic**: High biological production; nutrient rich.

VLAP uses the measure of **chlorophyll-a** as an indicator of the algae abundance. Because algae is a plant and contains the green pigment chlorophyll, the concentration of chlorophyll measured in the water gives an estimation of the concentration of algae. If the chlorophyll-a concentration increases, this indicates an increase in the algal population. Generally, a chlorophyll-a concentration of less than 5 $mg/m^3$ typically indicates water quality conditions that are representative of **oligotrophic** lakes, while a chlorophyll-a concentration greater than 15 $mg/m^3$ indicates **eutrophic** lakes. A chlorophyll concentration greater than 10 $mg/m^3$ generally indicates an algae bloom, an undesirable reproduction of algae, is occuring.

**Median:** A value in an ordered set of values below and above which there is an equal number of values (i.e.; the 50th percentile). Medians are not affected by outlier data.

**Mean:** The average of a set of values. Means can be affected by outlier data.

The **median** chlorophyll concentration for New Hampshire lakes is **4.58 $mg/m^3$** and the **mean** is **7.16 $mg/m^3$**. Figure 1 in Appendix A and Table 1 in Appendix B present the mean chlorophyll-a concentration for each year of participation in VLAP. Table 1 also presents the minimum and maximum values recorded for the same years.

| Category | Chlorophyll-a (mg/m3) |
|---|---|
| Good | 0 - 5 |
| More than desirable | 5.1-15 |
| Nuisance amounts | >15 |

## Phytoplankton

**Plankton net**: Fine mesh net used to collect microscopic plants and animals.

**Cyanobacteria**:Bacterial microorganisms that photosynthesize and may produce chemicals toxic to other organisms, including humans.

**Succession**: The decline of dominant species of algae over a period of time as another species increases and becomes dominant.

The type of phytoplankton present in a lake can be used as an indicator of general lake quality. The most direct way to obtain phytoplankton information is to collect a plankton sample at the deep spot using a **plankton net**, count the quantity of phytoplankton contained in the sample, and identify the species present in the sample using a microscope. An abundance of **cyanobacteria**, such as *Anabaena, Aphanizomenon, Oscillatoria,* or *Microcystis* may indicate an excessive phosphorus concentration or that the lake ecology is out of balance. On the other hand, diatoms such as *Asterionella, Melosira,* and *Tabellaria* or golden-brown algae such as *Dinobryon* or *Chrysosphaerella*, are typical phytoplankton found in New Hampshire's less productive lakes. In shallow warm waters with minimal wave action such as a cove, filamentous green algae may grow and form what looks like a mass of green cotton candy.

Phytoplankton populations undergo a natural **succession** during the growing season. Many factors influence this succession: amount of light, availability of nutrients, temperature of the water, and the amount of grazing occurring from zooplankton. As shown in the diagram on the next page, it is natural for diatoms to be the dominant species in the spring and then green algae in the early summer, while cyanobacteria may dominate in mid to late summer. The phytoplankton samples from your lake will show different dominant species, depending on when the samples were taken. Phytoplankton are identified in Table 2 in Appendix B. Phytoplankton groups and species are listed below.

**Phytoplankton Groups and Species Common to New Hampshire Lakes and Ponds**

**Greens**

| | | | |
|---|---|---|---|
| *Actinastrum* | *Eudorina* | *Pandorina* | *Spirogyra* |
| *Arthrodesmus* | *Kirchneriella* | *Pediastrum* | *Staurastrum* |
| *Dictyosphaerium* | *Micractinium* | *Scenedesmus* | *Stigeoclonium* |
| *Elakotothrix* | *Mougeotia* | *Sphaerocystis* | *Ulothrix* |

**Diatoms**

| | | | |
|---|---|---|---|
| *Asterionella* | *Melosira* | *Rhizosolenia* | *Synedra* |
| *Cyclotella* | *Pleurosigma* | *Surirella* | *Tabellaria* |
| *Fragilaria* | | | |

**Dinoflagellates**

| | | |
|---|---|---|
| *Ceratium* | *Peridinium* | *Gymnodinium* |

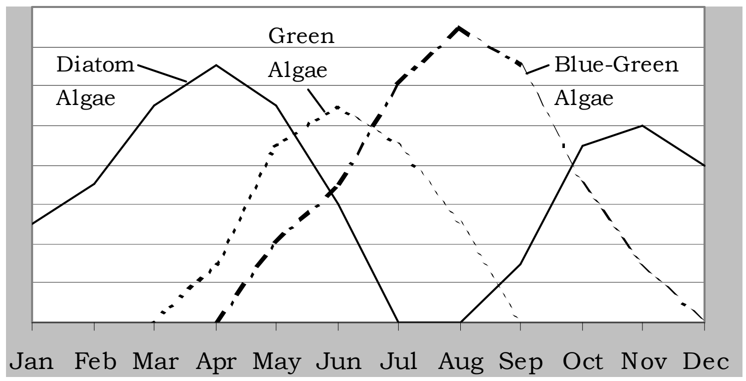
**Cyanobacteria (formerly known as blue-green algae)**

| | | | |
|---|---|---|---|
| *Anabaena* | *Chroococcus* | *Gloeotrichia* | *Microcystis* |
| *Aphanizomenon* | *Coelosphaerium* | *Lyngbya* | *Oscillatoria* |
| *Aphanocapsa* | | | |

**Golden-Browns**

| | | | |
|---|---|---|---|
| *Chrysosphaerella* | *Mallomonas* | *Synura* | *Uroglenopsis* |
| *Dinobryon* | | | |

**A Typical Seasonal Succession of Lake Algae**




## Cyanobacteria

**Cyanobacteria**:Bacterial microorganisms that photosynthesize and may produce chemicals toxic to other organisms, including humans.

**Cyanobacteria** are bacterial microorganisms that photosynthesize. Many species of cyanobacteria may accumulate to form surface water blooms. They produce a blue-green pigment but may impart a green, blue, or pink color to the water. Cyanobacteria are some of the earliest inhabitants of our waters, and they are naturally occurring in all of our lakes. They are part of the aquatic food web and can be eaten by various grazers in the lake ecosystem, such as zooplankton and mussels. Research indicates that their abundance increases as the phosphorus in a lake increase.

Although they are most often seen when floating near the lake surface, many cyanobacteria species spend a portion of their life cycle on the bottom of the lake during the winter months. As spring provides more light and warmer temperatures, cyanobacteria move up the water column and eventually rise toward the surface where they can form dense blooms or scums, often seen in mid to late summer and, weather permitting, sometimes well into the fall.

Some cyanobacteria produce toxins that adversely affect livestock, domestic animals, and humans. According to the World Health Organization (WHO), toxic cyanobacteria are found worldwide in both inland and coastal waters. The first reports of toxic cyanobacteria in New Hampshire occurred in the 1960s and 1970s. During the summer of 1999, several dogs died after ingesting toxic cyanobacteria from a bloom in Lake Champlain in Vermont. The WHO has documented acute impacts to humans from cyanobacteria from the U.S. and around the world as far back as 1931. While most human health impacts have resulted from ingestion of contaminated drinking water, cases of illnesses have also been attributed to swimming in waters infested with cyanobacteria.

The possible effects of cyanobacteria on the "health" of New Hampshire lakes and their natural inhabitants, such as fish and other aquatic life, are under study at this time. The Center for Freshwater Biology (CFB) at the University of New Hampshire (UNH) is currently examining the potential impacts of these toxins upon the lake food web. The potential human health hazards via exposure through drinking water and/or during recreational water activities are also a concern to the CFB and DES.

Cyanobacteria occur in all lakes, everywhere. There are many types of cyanobacteria in New Hampshire lakes. Most cyanobacteria do not have the ability to produce toxins. In New Hampshire, there are several common cyanobacteria that include: *Gleotrichia, Merismopedia, Anabaena, Oscillatoria, Coelospharium, Lyngba* and *Microcystis*. *Anabaena* and *Aphanizomenon* produce **neurotoxins** that interfere with the nerve function and have almost immediate effects when ingested. *Microcystis* and *Oscillatoria* are best known for producing **hepatotoxins** known as microcystins. *Oscillatoria* and *Lyngbya* produce **dermatotoxins** which cause skin rashes.

**Neurotoxin**: Nerve toxins.

**Hepotoxins**: Liver toxins.

**Dermatoxins**: Toxins that cause skin irritations.

Both DES and UNH have extensive lake monitoring programs. Generally, the water quality of New Hampshire's lakes is very good. However, DES strongly advises against using lake water for consumption, since neither in-home water treatment systems nor boiling the water will eliminate cyanobacteria toxins if they are present.

If you observe a well-established potential cyanobacteria bloom or scum in the water, please do the following:

- Do not wade or swim in the water!
- Do not drink the water or let children drink the water!
- Do not let pets or livestock into the water!

Exposure to toxic cyanobacteria scums may cause various symptoms, including nausea, vomiting, diarrhea, mild fever, skin rashes, eye and nose irritations, and general malaise. If anyone comes in contact with a blue-green algae bloom or scum, they should rinse off with fresh water as soon as possible.

**If you observe a Cyanobacteria scum, please call DES at 271-3414.** DES will sample the scum and determine if it contains cyanobacteria that are associated with toxic production. An advisory will be posted on the immediate shoreline indicating that the area may not be suitable for swimming. DES will issue a press release and will notify the town health officer, beach manager, and/or property owner, and the New Hampshire Department of Health and Human Services. DES will continue to monitor the water and will notify the appropriate parties regarding the results of the testing. When monitoring indicates that cyanobacteria are no longer present at levels that could harm humans or animals, the advisory will be removed.

## Secchi Disk Transparency

The Secchi Disk is a 20 centimeter disk with alternating black and white quadrants. It has been used since the mid-1800s to measure the transparency of water. The Secchi Disk is named after the Italian professor P.A. Secchi whose early studies established the experimental procedures for using the disk. Transparency, a measure of the water clarity, is affected by the amount of algae, color, and particulate matter within a lake. In addition, the transparency reading may be affected by wave action, sunlight, and the eyesight of the volunteer monitor. Therefore, it is recommend that two or three monitors take a Secchi Disk reading, and then these readings should be averaged.

**Viewscope:** A white plastic PVC pipe with a clear plexiglas end.

Starting with the 2007 sampling season, DES recommends that all volunteer groups collect transparency readings with and without the use of a **viewscope**. A comparison of the transparency readings taken with and without the use of a viewscope indicates that the use of a viewscope typically increases the depth to which the Secchi Disk can been seen, particularly on sunny and windy days. The use of the viewscope results in less variability in transparency readings between monitors and between sampling events.

In general, a transparency greater than 4.5 meters indicates oligotrophic conditions, while a transparency of less than 2 meters is indicative of eutrophic conditions.

**Median:** A value in an ordered set of values below and above which there is an equal number of values (i.e.; the 50th percentile). Medians are not affected by outlier data.

**Mean:** The average of a set of values. Means can be affected by outlier data.

The **median** transparency for New Hampshire lakes is **3.2 meters** and the **mean** transparency is **3.7 meters**. Figure 2a and 2b in Appendix A presents a comparison of the transparency values for each of the VLAP monitoring years without and with the use of a viewscope, respectively. Table 3a and 3b of Appendix B shows the minimum, maximum, and mean transparency values without and with the use of a viewscope, respectively, for all years of participation.

**Water Clarity (Transparency) Ranges for Lakes and Ponds**

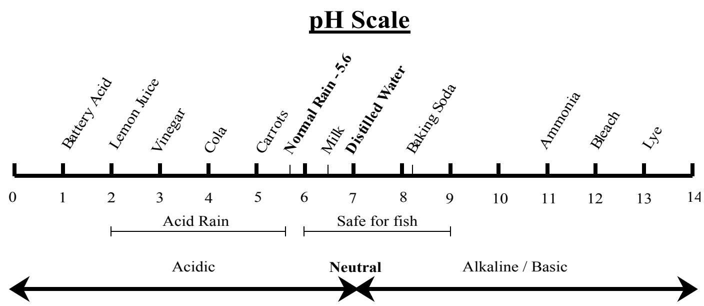
| Category | Water Clarity (m) |
|---|---|
| Poor | <2 |
| Good | 2-4.5 |
| Exceptional | >4.5 |

**Turbidity:** The amount of suspended particles in water, such as clay, silt, and algae that cause light to be scattered and absorbed, not transmittted in straight lines through the water.

Correlations between transparency and chlorophyll-a are an important indicator of lake quality. If the deep spot chlorophyll-a increased and the Secchi Disk transparency decreased, increased algae populations are likely affecting the water clarity. If the chlorophyll-a has not increased, but the transparency has decreased, the reduced transparency could be attributed to increased **turbidity** caused by stream inputs, motorboat activity, shoreline construction, or disturbances of bottom sediments.

## Chemical Parameters

### pH




pH is measured on a logarithmic scale of 0 to 14. The lower the pH the more acidic the solution, due to higher concentrations of hydrogen ions. Acid rain typically has a pH of 3.5 to 5.5 due to pollutants added from the air. In contrast, the **median** pH for New Hampshire lakes is **6.6**.

**Median:** A value in an ordered set of values below and above which there is an equal number of values (i.e.; the 50th percentile). Medians are not affected by outlier data.

**Thermally stratified**: Water layered by temperature differences. During the summer, cooler, more dense water is typically found closer to the lake bottom, while warmer, less dense water is found closer to the lake surface.

**Bacteria**: Tiny organisms that break down dead matter.

Lake pH is important to the survival and reproduction of fish and other aquatic life. A pH below 5.0 severely limits the growth and reproduction of fish. A pH between 6.0 and 7.0 is ideal.

Many lakes exhibit lower pH values in the deeper waters than nearer the surface. This effect is greatest in the bottom waters of a **thermally stratified** lake. Decomposition carried out by **bacteria** in the lake bottom causes the pH to drop, while photosynthesis by phytoplankton in the upper layers causes the pH to increase. Tannic and humic acids released into the water by decaying plants can create more acidic waters particularly in areas influenced by wetlands. After the spring-time snow melt or a significant rain event, surface waters may have a lower pH than deeper waters and may take several weeks to recover, since snowmelt and rainfall typcially have pH values of 4 or lower.

Table 4 in Appendix B presents the in-lake and tributary true mean pH data.

**pH Ranges for New Hampshire Lakes and Ponds**

| Category | pH (units) |
|---|---|
| Critical (toxic to most fish) | <5 |
| Endangered (toxic to some aquatic organisms) | 5-6 |
| Satisfactory | >6 |

## Acid Neutralizing Capacity

Buffering capacity or acid neutralizing capacity (ANC) describes the ability of the lake to resist changes in pH by neutralizing the acidic input to the lake. The higher the ANC the greater the ability of the water to neutralize acids. This concept can be compared to a person taking an antacid to neutralize stomach acid indigestion. Low ANC lakes are not well-buffered. These lakes are often adversely affected by acidic inputs.

Historically, New Hampshire has had naturally low ANC waters because of the prevalence of granite bedrock. Granite contains only a small amount of buffering elements such as calcium. The **median** ANC for New Hampshire lakes is **4.9 mg/L** while the **mean** ANC is **6.6 mg/L**. This relatively low value makes these surface waters vulnerable to the effects of acid precipitation. Table 5 in Appendix B presents the mean epilimnetic ANC for each year the lake has been sampled.

**Median:** A value in an ordered set of values below and above which there is an equal number of values (i.e.; the 50th percentile). Medians are not affected by outlier data.

**Mean:** The average of a set of values. Means can be affected by outlier data.

**Acid Neutralizing Capacity Ranges for New Hampshire Lakes and Ponds**

| Category | ANC (mg/L) |
|---|---|
| Acidified | <0 |
| Extremely Vulnerable | 0-2 |
| Moderately Vulnerable | 2.1-10 |
| Low Vulnerability | 10.1-25 |
| Not Vulnerable | >25 |

## Conductivity

**Ionic particle(s)**: An atom or group of atoms carrying an electrical charge. Typically, salts, minerals, and metal atoms.

**Non-point source pollution**: Pollution originating from a diffuse area (not a single point) in the watershed, often entering the water body via surface runoff or groundwater.

**Point source pollution:** Pollution often resulting from discharges into water from identifiable sources (points), such as industrial waste or municipal sewers.

Conductivity is the numerical expression of the ability of water to carry an electrical current. It is determined primarily by the number of **ionic particles** present. The soft waters of New Hampshire have traditionally had low conductivity values, generally less than 50 uMhos/cm. However, specific categories of good and bad levels cannot be constructed for conductivity because variations in watershed geology can result in natural fluctuations in conductivity. Generally, values in New Hampshire lakes exceeding 100 uMhos/cm indicate cultural, meaning human, disturbances. An increasing conductivity trend typically indicates **point source** and/or **non-point sources** of pollution are occuring within the watershed.

The **median** conductivity for New Hampshire lakes is **40.0 uMhos/cm** while the **mean** conductivity is **59.4 uMhos/cm**. Table 6 in Appendix B presents mean conductivity values for tributaries and in-lake data.

**Lake aging:** Nautral process by which a lake fills-in over time.

**Watershed:** The land that drains to a particular body of water.

**Eutrophication:** Lake aging accelerated by the increased nutrient input exceeing the natural supply.

**Cultural eutrophication:** When increased nutrient input and debris into a lake is caused by human activity.

**Phosphorus:** The most important parameter measured in NH lakes becuase it is typically the nutrient that determines the rate of lake aging.

**Limiting nutrient**: Nutrient that, in small increase, can cause larger changes in biological production.

**Biological Production:** Total amount or weight of living organisms.

**Oligotrophic**: Low biological production and nutrients; highest lake quality classification.

**Eutrophic**: High biological production, nutrient rich; lowest lake quality classification.

**Epilimnion:** The upper, well-circulated, warm layer of a thermally stratified lake.

**Hypolimnion:** The deep, cold, relatively undisturbed bottom waters of a thermally stratified lake.

## Phosphorus

Like all of us, lakes age over time. **Lake aging** is the natural process by which a lake fills-in over thousands of years. Lakes fill-in with erosional materials carried in by tributary streams, with materials deposited directly through the air, and with materials produced in the lake itself. From the time a lake is created, the aging process begins. Although many New Hampshire lakes have the same chronological age, they fill-in at different rates due to differences in lake depth and size and individual **watershed** characteristics. **Eutrophication** is the term used to describe lake aging that is accelerated by the process of increased nutrient input to a lake.

Lakes can age more quickly than they would naturally due to human impacts, a process called **cultural eutrophication**. This accelerated aging results from watershed activities that increase nutrient loading and/or the deposition of other debris, such as fertilizing lawns, converting forest or pasture to cropland, and creating new impervious areas such as rooftops, parking lots, and driveways. Studies in New Hampshire have shown that phosphorus exports from agricultural lands is at least five times greater than from forested lands, and in urban areas may be more than 10 times greater than from forested lands.

The key nutrient in the eutrophication process is **phosphorus.** Phosphorus is the **limiting nutrient** in New Hampshire lakes; the greater the phosphorus concentration in a lake, the greater the **biological production**.

Phosphorus sources within a lake's watershed include septic system effluent, animal waste, lawn fertilizer, eroding roadways and construction sites, natural wetlands, and atmospheric deposition. Reducing the amount of phosphorus in a lake will typically result in reduced algal concentration.

A deep spot epilimnetic (upper layer) phosphorus concentration of less than 10 ug/L typically indicates **oligotrophic** conditions, while an epilimnetic concentration greater than 20 ug/L is indicative of **eutrophic** conditions. The **median** phosphorus concentration in the **epilimnion** layer of New Hampshire lakes is **12 ug/L**. The **median** phosphorus concentration in the **hypolimnion** is **14 ug/L**. Figure 3 in Appendix A shows the epilimnetic and hypolimnetic total phosphorus values for all sampling years. Table 8 in Appendix B presents mean total phosphorus data for in-lake and tributary data.

**Epilimnetic Total Phosphorus Ranges for New Hampshire Lakes**

| Category | TP (ug/L) |
|---|---|
| Ideal | <10 |
| Average | 11-20 |
| More than desirable | 21-40 |
| Excessive | >40 |

## Nitrogen

**Total Kjeldahal Nitrogen (TKN):** A measures the total concentration of nitrogen in a sample present as ammonia (a form of nitrogen found in organic materials, sewage, and many fertilizers) or bound in organic (living) compounds.

**Nitrite ($NO_2$) + Nitrate ($NO_3$):** A measure of the major inorganic species of nitrogen found in lake waters, and often used as a nitrogen source by algae. In New Hampshire lakes, nitrite nitrogen is extremely low so that $NO_2$ + $NO_3$ is essentially the same as $NO_3$.

Nitrogen is another nutrient that is essential for the growth of plants and algae. Nitrogen is typically the limiting nutrient in estuaries and coastal ecosystems and is not limiting in freshwater. Therefore, nitrogen is not typically sampled through VLAP. However, if phosphorus concentrations in freshwater are elevated, then nitrogen loading may stimulate additional plant and algal growth. Various forms of organic and inorganic nitrogen can be sampled, inlcuding **Total Kjeldahal Nitrogen**, **nitrite** and **nitrate**. Total nitrogen is the sum of nitrite, nitrate and total Kjeldahl nitrogen forms. The ratio of total nitrogen to total phosphorus (TN:TP) is used to determine which nutrient determines the amount of algae growth, meaning which nutrient is limiting, when other factors such as light and temperature are sufficient for growth. A value less than 15 indicates nitrogen is limiting while a value greater than 15 suggests phosphorus is limiting. Table 7a and 7b in Appendix B lists the nitrogen sampling data if your lake has been sampled for this parameter.

## Dissolved Oxygen and Temperature

The presence of dissolved oxygen is vital to bottom-dwelling organisms as well as fish and amphibians. If the concentration of dissolved oxygen is low, typically less than 5 mg/L, species intolerant, meaning sensitive, to this situation, such as trout, will be forced to move up closer to the surface where there is more dissolved oxygen but the water column is generally warmer, and the species may not survive.

Temperature is also a factor in the dissolved oxygen concentration. Water can hold more oxygen at colder temperatures than at warmer temperatures. Therefore, a lake will typically have a higher concentration of dissolved oxygen during the winter, spring, and fall than during the summer.

**Thermal stratification**: Water layering by temperature.

**ppm**: Parts per million; equal to mg/L.

**Internal phosphorus loading**: Addition of phosphorus to the hypolimnion from the lake sediments due to a chemical change initiated by low oxygen conditions.

At least once during each summer, a DES biologist measures the dissolved oxygen and temperature at set intervals from the bottom of the lake to the surface. These measurements allow us to determine the extent of **thermal stratification** as well as the lake oxygen content. Many of the more productive lakes experience a decrease in dissolved oxygen in the deeper waters as the summer progresses. Bacteria in the lake sediments decompose the dead organic matter that settles out of the water column. Decomposition is a process that depletes oxygen in the bottom waters. Since more productive lakes tend to have organic-rich sediments, there will be greater decomposition on the bottom of such lakes, potentially creating a severe dissolved oxygen deficit of less than 1 **ppm**. This low oxygen condition can then trigger phosphorus that is normally bound to the sediment to be released back into the water column, a process called **internal phosphorus loading**, which can cause additional algal growth.

**Thermocline**: Barrier between warm surface layer (epilimnion) and cold deep layer (hypolimnion) where a rapid decrease in water temperature occurs with increasing depth.

The dissolved oxygen percent saturation shows the percentage of oxygen that is dissolved in the water at a particular temperature and depth. Typically, during the summer, the deeper the reading, the lower the percent saturation due to decomposition occuring at the lake bottom. A high reading at or slightly above the **thermocline** may be due to a layer of algae, producing oxygen during photosynthesis. Colder waters are able to hold more dissolved oxygen than warmer waters, and, generally, the deeper the water, the colder the temperature. As a result, a reading of 9 mg/L of oxygen at the warm lake surface will yield a higher percent saturation than a reading of 9 mg/L of oxygen at 25 meters where the water is much cooler. Table 9 in Appendix B shows the dissolved oxygen/ temperture profile data for the current sampling year, and Table 10 shows historical hypolimnetic dissolved oxygen readings.

## Chloride

The chloride ion ($Cl^-$) is found naturally in some surface waters and groundwaters and in high concentrations in seawater. Higher-than-normal chloride concentrations in fresh water, due to table salt, typically sodium chloride, that is used on foods and present in body wastes, can indicate sewage pollution. The use of highway deicing salts can also introduce chlorides to surface water or groundwater.

Although chloride can originate from natural sources, most of the chloride that enters the environment in New Hampshire is associated with the storage and application of road salt. Road salt, which is most often sodium chloride, readily dissolves and enters aquatic environments in ionic forms. As such, chloride-containing compounds commonly enter surface water, soil, and ground water during late-spring snowmelt since the ground is frozen during much of the late winter and early spring.

Chloride ions are conservative, which means that they are not degraded in the environment and tend to remain in solution, once dissolved. Chloride ions that enter ground water can ultimately be expected to reach surface water and, therefore, influence aquatic environments and humans.

**Acute toxicity:** An adverse effect such as mortality or debilitation caused by an exposure of 96 hours or less to a toxic substance (i.e; short period of time).

**Chronic toxicity:** An adverse effect such as reduced reproductive success or growth, or poor survival of sensitive life stages, which occurs as a result of prolonged exposure to a toxic substance (i.e; long period of time).

Research has shown that elevated chloride levels can be toxic to freshwater aquatic life. Among the species tested, freshwater aquatic plants and invertebrates tend to be the most sensitive to chloride. In order to protect freshwater aquatic life in New Hampshire, the state has adopted **acute** and **chronic** chloride water quality standards of 860 and 230 mg/L, respectively, for surface waters.

The chloride content in New Hampshire lakes is naturally low **(median = 4 mg/L)** in surface waters located in remote areas away from habitation. Higher values are generally associated with salted highways and, to a lesser extent, with septic inputs. Table 13 in Appendix B lists the chloride data if your lake has been sampled for this parameter.

## Other Parameters

### Turbidity

Turbidity in water is caused by suspended matter, such as clay, silt, and algae that cause light to be scattered and absorbed, not transmittted in straight lines through the water. Secchi Disk transparency, and therefore water clarity, is strongly influenced by turbidity. High turbidity readings are often found in water adjacent to construction sites; during rain events unstable soil erodes and causes turbid water downstream. Also, improper sampling techniques, such as hitting the bottom of the lake with the Kemmerer bottle or stirring up the stream bottom when collecting tributary samples, may also cause high turbidity readings. The New Hampshire **median** for lake turbidity is **1.0 NTU**. Table 11 in Appendix B lists turbidity data for all sampling years.

**Statistical Summary of Turbidity Values for New Hampshire Lakes and Ponds**

| Category | Value (NTU) |
|---|---|
| Minimum | <0.1 |
| Maximum | 22.0 |
| Median | 1.0 |

### Bacteria

Surface waters contain a variety of microorganisms including bacteria, fungi, protozoa, and algae. Most of these occur naturally and have little or no impact on human health. Health risks associated with water contact occur generally when there is contamination from human sources or other warm blooded animals. Contamination arises most commonly from sources of fecal waste such as failing or poorly designed septic systems, leaky sewage pipes, nonpoint source runoff from wildlife habitat areas, or inputs from wastewater treatment plant outflows within a watershed. Swim beaches with heavy use, shallow swim areas, and/or poor water circulation also have commonly reported bacteria problems. Therefore, water used for swimming should be monitored for indicators of possible fecal contamination. Contamination is typically short-lived since most bacteria cannot survive long in surface waters as their natural environment is the gut of warm blooded animals. A recent study has shown that *E. coli* can live fairly long periods of time in the sediments.

**Pathogens**: Disease-causing organisms.

Specific types of bacteria, called indicator organisms, are the basis of bacteriological monitoring, because their presence indicates that sources of fecal contamination exist. Indicators estimate the presence and quantity of things that cannot be meaured easily by themselves. We measure these sewage or fecal indicators rather than the **pathogens** themselves to estimate sewage or fecal contamination and, therefore, the possible risk of disease associated with using the water.

New Hampshire closely follows the bacteria standards recommended by the U.S. Environmental Protection Agency (EPA). Following a 1988 EPA report recommending the use of *Escherichia coli (E.coli)* as a standard for public water supplies and human contact, DES followed suit by adopting *E.coli* as the indicator organism. The standards for Class B waters specify that no more than 406 *E. coli* counts/100 mL, or a geometric mean based on at least three samples obtained over a 60 day period, be greater than 126 *E. coli* counts/100 mL. Designated public beach areas and other Class A waters, have more stringent standards: 88 *E. coli* counts/100 mL in any one sample, or a geometric mean of three samples over 60 days of 47 *E. coli* counts/100 mL. Table 12 shows bacteria (*E. coli*) results for the current sampling year and for previous sampling seasons.